High Power Transmitter Uses TE_{11} Mode Suppressor

To prevent unwanted radition, a transmitter requires additional harmonic rejection

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A tropo scatter communications transmitter in the 755 to 985 MHz frequency range uses a high power amplifier (HPA) containing a 10 kilowatt klystron. To handle this average power level, 3-1/8-inch rigid coaxial transmission lines [1] are employed. This coaxial line size can propagate the TE_{11} mode above a cutoff frequency of approximately 1.713 GHz. This falls within the second harmonic band of the HPA with levels greater than –20 dBc (referred to carrier fundamental). These second harmonic emissions are not substantially reduced by an absorptive low pass filter or a high power duplexer that were designed for only TEM operation. To provide adequate second harmonic reduction, a longitudinal TE_{11} mode suppressor was needed.

3-1/8-inch rigid coaxial transmission line

To realize a 50-ohm characteristic impedance, the rigid transmission line uses thin wall copper tubing as an outer conductor with outer diameter of 3.25 inches and inner diameter of 3.027 inches. The center conductor outer diameter is 1.315 inches. The impedance (air line) is checked with the following equation [2]:

$$Z = 60 \ln\left(\frac{b}{d}\right) \quad (1)$$

where b = inner diameter of outer conductor = 3.027 inches; and d = outer diameter of inner conductor = 1.315 inches. The calculated impedance equals 50.02 ohms.

The cutoff frequency for the TE_{11} mode is obtained as follows [2]:

Fundamental Frequency in MHz	Second Harmonic Frequency in MHz
755	1,510
870	1,740
985	1,970

▲ **Table 1. Transmit frequency bands.**

$$F = \frac{7.51}{(b+d)} \quad (2)$$

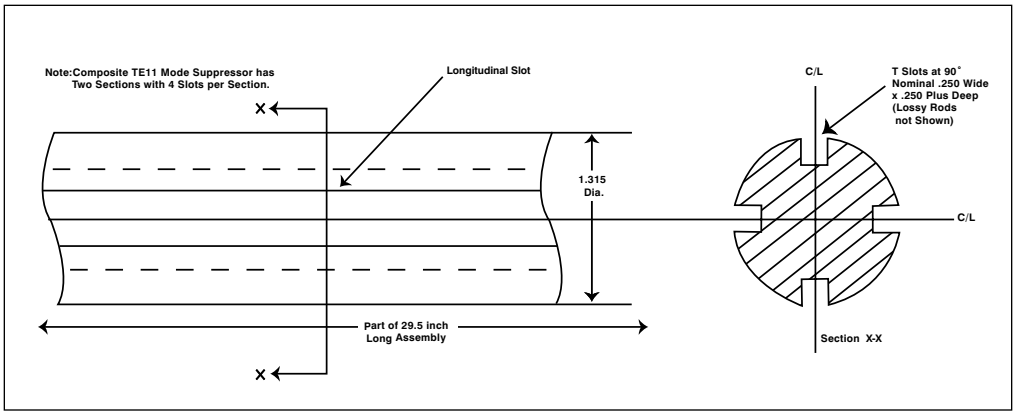
where F = cutoff frequency in GHz. The calculated cutoff frequency equals 1.731 GHz, which is equal to 1731 MHz.

Sections of the 3-1/8-inch-inch rigid coaxial line are mechanically supported at periodic intervals by commercially available teflon anchors. With unity VSWR, ambient temperature of 40 degrees C and one atmosphere absolute dry air pressure, the 3-1/8-inch-inch coaxial line can handle an average power level of 14 kilowatts [1].

The transmit frequency bands are shown in Table 1. More than half of the transmit second harmonic band is greater than the 1,731 MHz TE_{11} mode cutoff frequency.

TE_{11} mode suppressor details

The TE_{11} mode suppressor uses nominal 1/4-inch square lossy rods installed in longitudinal slots cut into the center conductor of the 3-1/8-inch-inch rigid coax line. The lossy rods attenuate the longitudinal current of the TE11 mode



▲ **Figure 1. A simplified view of the coaxial center conductor.**

without significantly affecting transmission of the dominant TEM mode.

The overall assembly is 29-1/2 inches long with Teflon® anchors at the ends and midpoint. The composite mode suppressor uses two cascaded sections of lossy rods that are 11-1/2 inches long. Each section contains four rods that are circumferentially located at 90-degree intervals. The rod material is a refractory ceramic that is capable of handling the 10 kilowatts average power level. The composite mode suppressor uses a total of eight rods. A simplified view of the coaxial center conductor is shown in Figure 1.

A crucial design detail is the mechanical retention of the rods in the center conductor's longitudinal slots. Custom designed metallic springs of 0.032 inch beryllium copper were created [3]. Each rod uses three springs. Each section (four rods) uses 12 springs. The overall mode suppressor (eight rods) uses 24 springs. Rod retention using epoxy was not viable at 10 kilowatts average power.

TE_{11} mode suppressor performance

Over the 755 to 985 MHz transmit band, the composite mode suppressor insertion loss was less than 0.1 dB and the return loss was greater than 21 dB. Transmitter operation was satisfactory at 10 kilowatts average power.

Conclusions

A TE_{11} mode suppressor was developed for an L band communications transmitter. Longitudinal lossy rods in the center conductor of 3-1/8-inch-inch rigid coaxial transmission line attenuated the transmit second harmonic with minimal degradation of the 10 kilowatt transmit TEM fundamental. ■

References

1. *Microwave Engineers Handbook, Volume 1,* Boston: Artech House, 1971: 103.

2. G.L. Matthaei, et al, *Microwave Filters, Impedance Matching Networks, and Coupling Structures,* New York: McGraw-Hill, 1964: 165,168.

3. S. Interlandi, Private Communication, 1970.

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